Burlington Northern Railroad Bridge (Willamette River Bridge 5.1) HAER No. OR-7
Spanning Willamette River at River Mile 6.9
Portland
Multnomah County
Oregon

HAER
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Western Region
Department of the Interior
San Francisco, California 94102

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HISTORIC AMERICAN ENGINEERING RECORD

Burlington Northern Railroad Bridge
(Willamette River Bridge 5.1)

HAER No. OR-7

Location:	Spanning the Willamette River at 6.9 miles south of its confluence with the Columbia River in northwest Portland, Oregon. UTM: 10.519845.5046855 Quad: Portland, Washington-Oregon
Dates of Construction:	August 1906 - October 1908. Major repairs in 1979, following damage by M/V Marie Bakke.
Present Owner:	Burlington Northern Railroad Company 9401 Indian Creek Parkway Overland Park, Kansas
Present Use:	Railroad swing bridge across the Willamette River.
Significance:	Willamette River Bridge 5.1 is the south end part of a 4-3/4 mile-long network of railroad bridges, causeways, and cut system linking the mainlines north and south of Portland. The bridge is one of the major works of renowned bridge engineer, Ralph Modjeski.
Recorder:	Alfred M. Staehli, Architect AIA, April 1985

Introduction

The network of Vancouver-Portland railroad bridges across the Columbia River was the first bridge link between Oregon and Washington States, crossing the Great River of the West, and providing the necessary rail link between the four major railroads which met in the Portland-Vancouver area: the Great Northern (GN) and Northern Pacific (NP) railroads and their subsidiary, the Spokane, Portland and Seattle Railway Company (SP&S) from the north side of the river, and the Oregon Railroad and Navigation Company (Union Pacific) and Southern Pacific Railroad from the Oregon side. Until the new bridges were built, the interchange of trains and cars was made by ferrys at Kalama and Vancouver, Washington. A highway bridge across the Columbia River, Interstate Bridge (US 99), would not be built until 1917.

The Vancouver-Portland bridges run in a generally north-south line from Willbridge in northwest Portland, across the Willamette River to the North Portland peninsula, through the Portsmouth Cut across the peninsula to Columbia Slough, across the slough on a short single span and along a railroad fill-dike dividing Smith and Force (now Vanport area) lakes, low flood plain areas of the Columbia River, to the Oregon Slough (North Portland Harbor), across on the Oregon Slough Bridge to Hayden (Shaw) Island[1] and along another fill, replacing the original Hayden Island Viaduct, to the Columbia River and the Vancouver Bridge. The total bridges, causeways, and cut complex is about 4-3/4-miles long from the north bank of the Columbia River to the south bank of the Willamette River. The bridges are comprised of 21 through truss bridge spans, three center swing draw spans, and three deck plate girder spans. The Willamette River Draw Span is the longest of the bridges, measuring 521 feet long. The Willamette River's four fixed through spans are identical with the six of the Vancouver Bridge, each 265 feet long. All piers are similar and constructed of granite ashlar faced plain mass concrete on timber piling or mass footings (see HAER photos OR-7-54 to OR-7-56). Timber caissons were used to build the piers (see HAER photos OR-7-70 and OR-7-78). The through truss fixed and draw spans are of the Pennsylvania (Petit) type of Parker truss.[2]

There are two systems of numbering for the bridges. The system of numbering used by the Coast Guard and the USGS identifies bridges by river mile distance from the mouth of the river which thus identifies the Willamette Bridge as No. 6.9 or 7. The railroad numbers the bridges in miles from Portland's

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1 McArthur, Lewis A., Oregon Geographic Names, 4th ed. (Portland: Oregon Historical Society, 1974), p. 374. Naming of Hayden Island with the previous names of Shaw, Vancouver, and Indian names.

2 Comp, T. Allan, Phd. and Donald Jackson, Bridge Truss Types: A Guide to Dating and Identifying, Technical Leaflet No. 95 (Nashville: American Association of State & Local History, 1977).

Union Station, with the Willamette Bridge identified as No. 5.1, Columbia Slough Bridge as No. 7.4, Oregon Slough Bridge as No. 8.8, and the Vancouver Bridge as No. 9.6. The Vancouver, Washington terminal is No. 10.

The railroads from the east and south, and river traffic (including ocean-going vessels and riverboats) made Portland a shipping and banking center of the 19th century Pacific Northwest. Construction of a Washington-Oregon Columbia River channel bridge began in 1890, "...only the pivot pier for the draw-span had been completed, and a few piles had been driven for the draw-rest pier, between the pivot pier and the shore."[3] After the successful Lewis and Clark Centennial Exposition of 1905, the city began a period of rapid growth which defined its pattern for the next half century. When, in 1902, railroad magnate James J. Hill announced that the Northern Pacific Railway Company planned to bridge the Columbia River and to dig a tunnel under North Portland's Peninsula district, the city was excited by the prospect of more jobs and economic development. Such a bridge connection was the last link in completing the network of railroad lines throughout the Portland-Vancouver region, the Columbia and Willamette river basin areas.[4]

Mr. Hill abandoned the idea of a tunnel through the peninsula, and proceeded to persuade the reluctant city to permit the SP&S to excavate a cut across the North Portland peninsula, a decision possibly influenced by the alternatives proposed in a 1905 report by the bridges' chief engineer, Ralph Modjeski.[5] Despite the fact that the railroad offered to construct four street viaducts across the cut, Portland Mayor Harry Lane vetoed the ordinance for the cut on the grounds that it was a land giveaway, a defacement of property, and a visual blight. However, business interests prevailed, and the Mayor's veto of the ordinance permitting the cut was overriden by the City Council.[6]

At the time of the bridge's completion, and for the next thirty years, the Port of Portland's drydock and ship repair facilities were located on the north bank of the Willamette River just west of the bridge (see HAER photographs OR-7-5, OR-7-7, and OR-7-13). The drydock facilities were moved to Swan Island after World War II to the site of the Kaiser shipyards.

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3 Modjeski, Ralph, The Vancouver-Portland Bridges, a report to the railroad companies, (Chicago: Ralph Modjeski, 1910), p. 9.

4 MacColl, E. Kimbark, The Shaping of a City: Business and Politics in Portland, Oregon 1885 to 1915 (Portland: Georgian Press, 2976), p. 310.

5 Modjeski, Vancouver-Portland, p. 7.

6 MacColl, Shaping, pp. 331-333.

Outline of Spokane, Portland and Seattle Railway Company History[7]

The present Burlington Northern bridge complex between Portland and Vancouver was the culmination of actions by the Northern Pacific Railway to continue control of the eastern traffic.

By 1876, Henry Villard controlled the Oregon & California Railroad, later the Southern Pacific, and in 1881, he took over the Northern Pacific. Simultaneously, he organized the Oregon Railroad and Navigation Company (OR&N) and completed the line from Portland to Wallula in 1882 to connect with the Northern Pacific. This line, in turn, was finished in 1883, giving Portland and the Pacific Northwest the first rail connection with the east. Puget Sound had no direct connections and depended upon the Tacoma-Portland line which crossed the Columbia River by train ferry from Kalama, Washington, to Goble, Oregon. In 1884, the OR&N was also completed to Huntington, Oregon, to connect with the Oregon Short Line, a Union Pacific (UP) subsidiary built west from Granger, Wyoming.

Villard lost control of the Northern Pacific in early 1884 but regained it in 1887. By then, the line was built across the Cascades from Pasco to Tacoma, Washington, but the Union Pacific had taken over the OR&N, so they controlled the only access down the Columbia River to Portland. In 1889, a subsidiary of the Union Pacific, along with the Great Northern Railway, located a line from Vancouver to Kalama, Washington, and applied for a bridge across the Columbia River at Vancouver. There was much maneuvering by the various railroads but little actual construction. Villard's departure in 1890 and the panic of 1893 stopped all activity. Both the NP and UP went into bankruptcy in 1893, and nothing further happened until Edward H. Harriman took over the Union Pacific in 1898.

The Union Pacific regained control of the OR&N in 1899, and the Northern Pacific, now allied with James J. Hill and the Great Northern, organized the Spokane, Portland & Seattle Railway Company to erect a railroad line down the north bank of the Columbia River. While this plan was partly to prevent the Chicago, Milwaukee & St. Paul Railroad from preempting the water level grade, it also served to regain direct eastern access to Portland. The new bridge complex was to be the pivotal link to both the line to the east and to the new direct line to Puget Sound by way of Vancouver and Kalama which eliminated the old train ferry. The other rivalries were resolved when, in 1909, the Union Pacific, Northern Pacific, and Great Northern railroads started joint service from Portland to Puget Sound and commenced building a modern double track line.

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7 This section was researched and written by Lewis L. McArthur on commission for this HAER project.

Construction of the Bridge

The Vancouver-Portland bridges were designed by the internationally recognized engineer, Ralph Modjeski, whose reputation as a major bridge designer began with the building of the Thebes Bridge (1904) across the Mississippi River at Thebes, Illinois. He designed the McKinley Bridge (1902-1910) in St. Louis, the Ohio River Bridge (1914-1917) at Metropolis, Illinois, and the Crooked River Bridge (1912) near Redmond, Oregon, as part of his long association with the railroads.

Modjeski began his investigation of the Burlington Northern Railroad Bridge in September 1905. He met with Mr. Benjamin L. Crosby, principal assistant engineer for the Pacific Division of the Northern Pacific Railways and examined the proposed crossing of the two rivers and the alternative routes in between them. He approved of the alignment previously surveyed by the railroad with two alternatives for crossing the Willamette River, one more north of the final route proceeded around St. John's Point, and the second in the direct line of the Columbia River Bridge through Portsmouth, the route adopted. Modjeski endorsed the previously-determined Columbia crossing because,

> ...the permission of the War Department will probably be more easily obtained for building a bridge on the site which has been approved once before than in an entirely new location. Another consideration, although perhaps of minor importance, is that this location would permit the use of the present pier, and a corresponding saving in cost of some $60,000 to $80,000.[8]

Modjeski also recommended the double tracking of the right of way and bridges as being more cost effective in the long run.

Preliminary construction work began in November 1905 at offices opened at the Vancouver end. Plans were submitted to the War Department of January 1906 and approved a month later. Work began on the Columbia River sections while negotiations with the Port of Portland were being concluded to fix the character and size of the Willamette River draw span. The Willamette River draw span as approved was the longest swing span in the world at that time. The conditions established by the Port of Portland for the design and operation of the new bridge were generally in conformance with the standards of the Secretary of War (Army Corps of Engineers) for the design of bridges across navigable waterways. The Port of Portland made two additional requirements: A higher clearance above low water level, putting the Portland bridge at a 16.62 foot higher elevation than the Vancouver bridge. The difference in

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8 Modjeski, Vancouver-Portland, p. 7.

elevation was accommodated by a slight incline grade through the Portsmouth Cut. The bridges were to be made available to competing railroads. Port of Portland approval was given in April 1906. War Department approval was given in June 1906.[9]

Construction work on the Willamette Bridge began in August 1906. Construction on the bridges and their approaches took two years. Superstructures were completed in July 1908, machinery work completed that October, and the first passenger train, Mr. James J. Hill's Special, passed over the bridges on November 5, 1908.[10]

Ralph Modjeski

Ralph Modjeski (1861-1940) was born in Krakow, Poland, and was expected to become a concert pianist. But, upon graduation from the Ecole des Ponts and Chaussees in Paris in 1885, he came to the United States to work with George S. Morris on the Union Pacific Railroad Bridge at Omaha and the Memphis Bridge. From his own office in Chicago in 1893, Modjeski began a remarkable career which saw the development of steel bridge construction through all its phases to the mid-twentieth century. Modjeski was to be a principal bridge engineer for the railroads and cities of America. Among his commissions are: Crooked River Bridge, Oregon; Philadelphia-Camden Bridge, Delaware River; Quebec Cantilever Bridge, Canada; the McKinley Bridge, St. Louis, Missouri; and Broadway Bridge, Portland, Oregon. The engineering firm which he established survives as Modjeski and Masters with offices in Harrisburg, Pennsylvania, and New Orleans, Louisiana.[11]

While his bridges exhibit the state-of-the-art of bridge building technology of his time, Modjeski is given recognition for having undertaken the most difficult and largest bridges of their types and for successfully completing them. Modjeski's Vancouver-Portland bridges for the SP&S Railway have been cited for several outstanding qualities. The Portland draw span is reported

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9 Port of Portland resolution, April 28, 1906, A. L. Pease, President, John P. Doyle, Clerk. War Department, Judge Advocate Generals Office, resolution June 20, 1906, Robert Shaw Oliver, Asst. Secretary of War. Copies of the Port of Portland and War Department letters and permits are from BN file No, 33-7, Portland office.

10 Modjeski, <u>Vancouver-Portland</u>, p. 8.

11 Plowden, David, <u>Bridges: The Spans of North America</u> (New York: The Viking Press, 1974), pp. 171-173. Whitney, Charles S., <u>Bridges: Their Art and Science</u> (New York: William Edwin Rudge, 1929), plates 336, 341, 370, 379, 388.

to have been the longest double-track swing span in the world at the time of its construction and remains one of the longest of its kind today.[12] It is also one of the largest, mostly rim-bearing swing bridges built at a time when center bearing was preferred, due to lower friction during turning. Modjeski states that his design called for 5/6 of the draw's weight to bear on the rim and 1/6 on the center bearing, where other engineers recommended equal distribution (see HAER photographs OR-7-8 and OR-7-12).[13] There also were concerns with differential settlement around masonry piers which would cause the rim to deflect and be uneven. Modjeski reported that, during the operational tests, he was surprised to find that the coefficient of friction was much less than he had planned, and that it was possible to lessen the gear reduction so the bridge could swing faster than had been anticipated, opening 90 degrees in 1-1/4 minutes.[14]

Description of Bridge

The bridge's through Pennsylvania (Petit) type Parker Truss design utilizes riveted box girders, beams, and lattice struts, pinned panel point connections, and heavy wrought bar ties. Modjeski designed the draw span with ten uniform 24 feet, 6 inch width panels on each side of a 31 feet, 0 inch center tower, again going against prevailing bridge design philosophy which preferred varying panel widths.[15] The bottom deck chord of each truss is straight. The top chords of the fixed side spans are segmentally curved with sloping portals. The draw span is similar but with six panel-straight sloping on each end and a five-panel hump over the center. The draw span is designed to function as a balanced cantilever span when open and as two simple spans when closed and locked to the draw rest supporting piers.[16] It appears from observing the truss panels, that Modjeski adapted the K-truss principles patented from Stephen H. Long (1830) which use intermediate struts to stiffen the main diagonal struts, resulting in a K pattern within a panel.[17]

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12 U. S. Coast Guard, Environmental Assessment for Burlington Northern Railroad Bridge Alteration Across the Willamette River, Mile 6.9, report August 13, 1984, p. 8.

13 Waddle, John A. Low, Bridge Engineering (New York: J. A. Wiley & Sons, 1916), pp. 680, 684-699.

14 Modjeski, Vancouver-Portland, p. 15.

15 Op. cit., p. 481.

16 Modjeski, Vancouver-Portland, Strain Sheet, Willamette River Bridge, Draw Span, plate LIII.

17 Condit, Carl W., American Building (Chicago: Univ. of Chicago Press, 1968), p. 224.

The draw span's center tower panel is designed as a braced frame, three panels high. The center tower supports the cantilevered draw spans when open and is largely redundant, self support only when the draw is closed. The two simple spans, partially continuous, of the draws are designed to undergo a stress reversal in their top and bottom chords when changed from closed and end supported to open cantilevered positions. Inspection shows that certain struts and ties are designed to preserve their function during this reversal; a rod tie may not function as a strut. Portal, intermediate, and center cross bracing provides for lateral stability of the through truss assemblies.

The materials specified for the bridge, wrought iron and steel, cast iron, and cast steel, represented the state of steel construction technology at the time, in accordance with Association for American Steel Manufacturers for Structural Steel 1903 specifications, a precourser of the current American Institute of Steel Construction (AISC) specifications. The specifications are in general conformance with the 1912 American Bridge Company and American Society for Testing and Materials specifications A9 1901-09, as published in a Carnegie Steel Company 1917 manual. A minimum wrought steel elastic limit (yield) strength of 35,000 pounds per square inch was specified. The riveted connections in the assembly specified especially reamed and aligned holes during fabrication to attain maximum strength from the fastenings. The bridge remains fully operational and in excellent condition, without significant alterations since built, and in conformance with modern loading requirements.

Fabricated steel and iron work was to be cleaned and protected with one coat of red lead in oil primer paint except for certain finished surfaces where white lead and tallow or plain linseed oil coatings are specified. Modjeski states that the Willamette River spans were finished after erection with two coats of "Nobrac" paint, an old brand name which appears to have been a special marine air corrosion resisting finish.[18] The original color was probably a carbon or graphite black, as used on the other spans. When the finish colors were changed to the present aluminum pigmented finish is not recorded, but presumably in the later 1930s or 1940s after aluminum pigmented industrial finishes became popular.

Bridge piers were built, using pneumatic caissons sunk to the river bottom. The main Willamette River piers are supported on concrete footings bearing on the coarse gravel and rock subgrade of the channel. Only the end abutment piers and north pier "A" have pile supports. Caissons were built of caulked

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18 Modjeski, Vancouver-Portland, p. 16. The name, "Nobrac," suggests roots in either the words brackish, referring to saline water, or break, a flaw in a surface or coating; in either case applicable to a protective coating for ferrous metals exposed in extreme weather conditions.

timbers and closed with pressure hatches of iron.[19] The Willamette caissons had to be placed from special barges from which they were lowered by long suspension screws, except for the draw span Pier III which had to be sunk with its barges because of its size (see HAER photograph OR-7-55). Plain concrete was placed pneumatically on the excavated subgrade within the caisson air chambers. Once the bottom was sealed, the caisson could be emptied of water and the remaining concrete and any ashlar facings placed until above water level. The draw span pier is constructed full height of plain mass concrete, octagonal in section, 47 feet, 8 inches across, with a two course ashlar coping. The draw span pier is almost totally hidden by the timber piling and sheathing of the draw protection, or shear fence (see HAER photographs OR-7-4, OR-7-14, OR-7-49 and OR-7-55).

The timber shear fence has been rebuilt and repaired many times (see HAER photographs OR-7-7, OR-7-47, OR-7-48, OR-7-49). Its most recent reconstruction was after the 1978 collision of the M/V Marie Bakke with the fence and draw span. The records on the bridge show that some part of the piling and sheathing timbers are replaced several times a year because of damage by steamers or riverboats and their tows (it might appear that elimination of this swing span draw and its protection will cost local contractors tens of thousands of dollars in repair contracts generated by the several collisions each year). Principal changes in the shear fence from its original configuration have been in removing the taper indicated on the Modjeski plan and in regular changes in the installation of navigation lights and safety markers associated with the draw. Originally, there was to have been a platform and capstan on the downstream works for the emergency manual operation of the draw, possible removed sometime in the early 1930s or before (see HAER photographs OR-7-76 and OR-7-86).[20]

The turntable and draw operating machinery is outlined in Modjeski's report. The published Modjeski report has a single drawing (LIV) of a half-section through the center which shows the drum and track but none of the turning machinery. Modjeski describes the machinery and operation:

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19 Smith, H. Shirley, "Bridges and Tunnels," Chapter 21, Singer's A History of Technology, v. 5 (London: Oxford University Press, 1958), pp. 514-516.

20 My father, Ralph J. Staehli, operated the Bonneville Navigation Company from 1936 to 1941, running excursions from Portland to Bonneville Dam and in the Portland harbor. I passed through this SP&S Railway bridge many times and do not remember seeing any of the manual operating gear. See Appendix 2, Interview with Louis DeGrandpre and Art Hansen, p. 31.

> The turntable is part rim--and part center-bearing, the load being distributed in the proportion of five-sixths to the rim, and one-sixth to the center. In view of its large proportions, and great frequency of operation, more than ordinary care was exercised in the design of the operating mechanism. The navigation is open the year around; there is no period of closed navigation in which to make repairs. To provide for possible derangement of parts of the swinging machinery, the main pinions and all gears, shafts, etc., were made strong enough to operate the draw at reduced speed, by one pinion only, and by one motor on its overload capacity. The general arrangement of the swinging machinery is the same as in the Vancouver draw (many parts are interchangeable), excepting that all the details are much heavier and entirely of steel. There are two motors of seventy horsepower rated capacity, capable of a short time overload three times greater. As a matter of fact, the friction of the various parts of the turntable proved to be less than the one assumed in the calculations, and the draw operated the ninety degrees in 1-1/4 minutes. The gear ratio was subsequently reduced and slow speed gears added for emergency. As in the Vancouver draw, there are two independent sources of power provided. The gasoline engine is 165 horsepower, four cylinder vertical type. It is directly connected with the generator,, and is intended to act as auxiliary power, the current from outside being used to operate the bridge under all ordinary circumstances. A third, or emergency motor, has been placed in position, and may be quickly connected to the gears. As an additional precaution, a hand-turning device has been installed, consisting of capstans placed on the protection, and cables which can be attached to the drum when needed. It is estimated that ten men can swing the draw by hand ninety degrees in twenty minutes (see HAER photographs OR-7-71, OR-7-72, OR-7-73, OR-7-77, OR-7-79, OR-7-80, OR-7-81 and OR-7-82).

American Bridge Company of New York contracted the fabrication of the bridge superstructure including the draw span turntable. Otto Gas Engine Works, Chicago, was the contractor for all turning machinery on the Willamette River draw. As originally built, the machinery is primary electrically-powered and -controlled The present turning machinery appears to conform to the original configuration as described by Modjeski and indicated on the drawings, which includes two primary drive motors, south Motor No. 1 and north Motor No. 2, and the auxiliary motor in the center of the turntable. Motors number 1 and 2 are connected to the turning gear train by a main drive pinion gear. Immediately adjacent to the two motors is an air-brake to slow or stop the turning motion (see HAER photographs OR-7-2 to OR-7-15). Most of the turning machinery parts are interchangeable between the Vancouver-Portland draws.

Turning Machinery

Only the auxiliary motor has a data and serial number plate attached. This motor, which appears identical to the two main motors, is a Westinghouse

75-horsepower, 550-volt/3-phase/60-cycle induction motor. There were no records of motor replacement, and the existing motors are presumed to be the original ones.

The auxiliary motor is direct connected to a longitudinal drive shaft which extends to the same gear trains driven by the two main motors. At the main drive gears, there is a sliding drive pinion gear at each end of the auxiliary drive shaft which is manually engaged with the drive gear when necessary. This motor is normally out of service and is not connected to the normal operating control circuit and electric power. Its operation must be manually engaged and switched at the main load panel within the drum area.

As originally built, the bridge was supplied with commercial electric power for its operation. Emergency on-site power was generated by a gasoline engine-generator set installed within the Bridgetender's house, up in the center tower (see HAER photograph OR-7-79). According to Modjeski's specifications, the generator set consisted of a four-cylinder gasoline engine with its supporting fuel and starting equipment and its direct connected dynamo and belt-driven exciter units. This installation is seen in the construction drawings. Burlington Northern records indicate that this emergency power generation equipment was removed in November 1963, because of new provisions for electric service from two sources, at the same time as the installation of electric heating to replace the former oil heater.[21] Electric power now comes from both ends of the bridge, normally Portland General Electric Company with backup from Pacific Power & Light Company. Electric service to the bridge is by wires on poles. From the service transformers, the electric service runs along the fixed spans in a conduit to the draw rest piers, where it goes to the draw pier in a submarine cable. Power from the fixed pier is conducted to the rotating draw span through a set of collector rings and contacts around the center pivot post, under the machine room (see HAER photograph OR-7-8). The main power panels and disconnects are located right above at the center of the machinery room inside the drum (see HAER photograph OR-7-3).

Drive power is transmitted from the motors, normally both in operation, through opposite sets of drive gears providing five reduction steps. The horizontal motor drives are changed to vertical drives by means of a cluster of bevel equalizer gears. The two drive trains on each side are required for backup and to provide for simultaneous rotation of pairs of bull shafts in the same direction. Through this fear train, each motor turns two vertical bull shafts under each draw span. At the bottom of each bull shaft, the bull shaft pinion turns on the bull ring gear and rotates the superstructure about its center

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21 Burlington Northern memorandum, November 15, 1963, file 33-7, Portland office.

(see HAER photographs OR-7-9, OR-7-13, OR-7-14 and OR-7-15). Machinery was overhauled before the Marie Bakke accident in 1957.[22]

As previously stated, all cables, pulleys, and the capstan for emergency manual draw operations have been removed. Only the shackle links on the base of the drum remain from the manual operation system. These links proved useful when temporary operation of the draw without its machinery was needed following the Marie Bakke accident; and the draw was turned by attached cables pulled by tug boats.

According to the older operators, the bridge's machinery was formerly lubricated by manually turning the hand-filled grease cups at each fitting. Gears were always hand lubricated with grease applied with wooden paddles. Now, all bearings are lubricated with hand-operated pressure guns and Alemite type fittings. The center pivot is provided with gravity oil cup (see HAER photograph OR-7-11). Lubricants both protect bearing and meshing surfaces from wear and protect them from rusting. Most of the machinery was originally exposed to the weather, only nominally sheltered under the bridge deck. The two drive motors and brakes and the auxiliary motor are now sheltered within wood frame and plywood sheathed huts built inside the drum's machinery room.

The swing span's end lock machinery is comprised of the end lock and support pier jack drive and linkage and the rail lock mechanisms. The machinery is motor-driven through a gear train located under the bridge deck between the tracks. The final drive is a quadrant gear which rotates a crank shaft with counter-weighted crank arms on each end outside the tracks, in line with the truss panels. A crank arm on each side pulls to unlock or pushes to lock the articulated end lock and jack linkages contained within the end post structure and which swing from a top mounted pin. When closed and locked, this linkage makes a rigid braced column of support from the top pin down to the support stool installed on top of the pier and locks the spans in alignment (see HAER photographs OR-7-32, OR-7-33, OR-7-34, OR-7-43 and OR-7-74).

Accessory to the end lock machinery, the rail locks are driven in or withdrawn by a motor-driven crank, aligning the rail ends between the spans and making or breaking the signal connections (shore boxes) between the spans (see HAER photographs OR-7-44, OR-7-75, OR-7-83 and OR-7-84). The sequence of operations which lock and unlock and swing the draw are regulated by mechanical interlocks under the control handles of the operator's console and by signal lights on the control and signal panel in the Bridgetender's house. The Bridgetender manually resets the train signals before and after swinging the draw (see HAER photographs OR-7-17, OR-7-17, OR-7-18, OR-7-80 and OR-7-81).

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22 BN letter, March 9, 1957, file 33.7

The bridge deck is built of preservative-treated wood ties laid normal to the longitudinal deck beams. Between the tracks, there is a plank walkway. Refuge and maintenance platforms are located at the center of the draw and toward each end outside the tracks. Originally, railroad signal and telegraph wires were carried across the span on the upstream side on bracket-mounted crossarms and glass insulators. The deck construction continues through all fixed spans on either end.

The Bridgetender's house is a wood frame structure, supported by the center tower above the train level. It was extensively rehabilitated and altered in 1963 when its heating was modernized and the standby generator system removed. There is a wood perimeter deck with T&G flooring. The exterior is painted sheet metal clad. Replacement aluminum casement sash has been installed. The interior ceiling has been lowered. Interior finishes are painted plywood and wood trim, resilient flooring, predominantly railroad maintenance blue-gray and aluminum colors. The hip roof is painted standing seam metal. The house is in generally good condition. The exterior deck shows some deterioration. Sheet metal trim on the house, its rain gutters, and the weatherproofing of the roof and floor spaces are in poor condition.

The access stairway on the downstream side of the bridge appears substantially original except for normal replacement of the wooden step treads. There are steel ladders up to the top center of the tower and up the end portals for access to and maintenance of the bridge's marker lights.

Bridge Operation

Bridge communications and signals between the operators and the trainmasters and with river traffic has been modernized. Except for the signal system and derail operations, which are still manually operated from the bridge, most communications are now by telephone and radio. A double air horn signal is still used to give warnings of impending opening or closing of the draw and to signal operating troubles and opening and closing delays. Most river traffic now requests that the draw be swung by means of VHF radio-telephone, and information on train movements similarly comes by radio. Bridge 5.1's whistle signal is one long and one short blast.

Railroad safety rules and U. S. Coast Guard rules govern the operation of the bridge and the conduct of its operators. The record indicates that there have been regular improvements made in the bridge's clearance lighting and marker lights throughout the years. Lighting has changed from kerosene lamp fixtures to incandescent electric lighting (exact date not recorded). According to Burlington Northern Railroad Company <u>Timetable and Special Instructions No. 5</u>, October 1984, maximum speeds on the bridge are 25 MPH for passenger cars and 15 MPH for freight trains. Trains frequently cross the bridge in both directions at the same time. The present Coast Guard permit and rules require that the bridge be attended by an operator at all times. A single operator is on duty each of three shifts per day. A helper is on duty four days a week to perform the routine lubrication of the machinery and maintenance work. The helper is also a relief operator for one day, rotating as needed between the three draws of the Vancouver-Portland bridge system.

Bridgetenders are usually non-specialists who have been hired for the job after progressing from other railroad maintenance positions. Training as an electrician is considered to be desirable but not essential. Operators appear to have been trained for the tending job by observing other operators and on-the-job experience. The job is a lonely one, uneventful at best and accented by pure terror at the worst. Some operators spend the time reading. Watching from their high perch and seeing the seasons and weathers change are reported to be some of the rewards of the job; sunrises over the Cascade Mountains to the east are said to be especially dramatic from this viewpoint. Operators become familiar with the regular ships and towboats and their crews who pass through the draw. One operator reportedly completed his studies for college credits during his shifts. Their regular duties include recording information on all significant traffic through and across the bridge and reporting on all accidents and on the bridge's condition. Accident reports include notes on the time, weather condition, and visibility when the event occurred. Operators give their interpretation of any cause or fault in an accident. Except for the helper during the day, there are few visitors to the Bridgetender's house.[23]

Bridge operation is relatively simple. When the operator receives either a signal or radio telephone request from the trainmaster in Vancouver to swing the draw, he knows whether or not a train is due to cross during the time the draw would be open. If a scheduled passenger train is in the immediate vicinity or if another train is so close as to be difficult to stop, the operator will determine whether or not the requesting vessel can be slowed or stopped to permit the train to cross before opening the draw for the river traffic. The VHF radio telephone usually gives the operator long advance notice of a request to swing. Smaller vessels which do not have radio-phones are usually able to stop or circle while waiting for a train passage. Whenever possible, precedence is given to river traffic over trains.[24]

Before opening the draw, the operator acknowledges the signal or phone request and sounds his horn. He must first reset the signals to indicate no passage over the bridge and open the derails. The rail locks and shore boxes (signal connectors are withdrawn) (see HAER photographs OR-7-32 and OR-7-44). The ends

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23 See field records for transcripts of oral history interviews with one current and two retired operators.

24 Ibid.

are unlocked and the jacks retracted. The draw motors can then be energized to swing the draw. A stepping resister circuit, located in a wire mesh enclosed rack in the northeast corner of the control room, is used to regulate the speed of the motors. As the span is swinging, its momentum is used to continue the opening or closing, and the motors are turned off. Carefully judged timing of motor cutoff can bring the draw to its stopping point over the draw protection or the end support piers with little use of the air brakes. When motors are off and the bridge is "coasting," there is a remarkable sound of meshing gears and inertia driven motors, accented with occasional pulses of gear train backlash.

Under emergency conditions, when one or two motors fail or other mechanical difficulty, the bridge can be swung with only one motor or by manually engaging the auxiliary motor by sliding its drive pinion on its splined shaft. The duplexed drive system was designed so that any one of the four bull shafts could swing the bridge if necessary, although they all operate simultaneously under normal conditions.

Morphology of Bridge and Events[25]

Burlington Northern Railroad's records on Willamette River Bridge 5.1 do not go back before 1944. The region's engineering functions were consolidated in BN's Seattle, Washington, office two years ago and the older records were given or thrown away. Some records were donated to the Oregon Historical Society, but these appear to be limited to more general records and some scenic photographs unrelated to the Vancouver-Portland bridges, generally not organized and most inaccessible.

The consensus of views held by present and retired railroad men who worked for both the SP&S and BN railroads is that except for normal repairs, maintenance, and periodic shear fence replacement, the bridge remained generally as originally built until the rehabilitation of the draw machinery standby power system and the bridgetender's house in 1963 and the major restoration and repairs made following the Marie Bakke accident in 1978.

The World War II years appear to have been a peak period of collision incidents with the draw rest or shear fence. Navy ship and towboat accidents are frequently reported during the mid-1940s, apparently as a result of high activity in river traffic by wartime shipbuilding and salvage work as the war came to an end. Portland's sternwheeler towboats, steamers Clair, Henderson, and Portland, are frequently mentioned. The Steamer Portland became stuck under the draw in November 1944 because of a misunderstanding about the river level and clearance under the span. The Portland's stack passed safely, but

25 From notes made from documents in BN Railroad file 33-7, Portland office.

its kingpost was caught by the girders, doing little damage to the bridge but effectively pinning the ship. The river was in flood tide and the potential for additional damage to both bridge and steamer was great. The Portland's captain partially flooded the vessel's hull, extinguishing its boiler fires, to lower it clear of the draw. A Portland fire boat was enlisted to aid the flooding and to pump out the water after the boat was freed. The Portland's boiler fire had to be relit and steam raised before the ship could proceed to dock. No significant damages were reported to either the steamer or the bridge.

Despite a history of bridge fires on Portland's older bridges, the Willamette River SP&S bridge has had a relatively good fire safety record. Its deck consist of creosote-treated wood ties, and there is a substantial amount of oil-soaked wood framing under and around its central drum and machinery. The shear fence is entirely of timber construction. A 1949 fire in the center circle framework is reported to have been caused by welding sparks igniting oily rag wastes. The fire was extinguished by a fire boat. Damage was confined to the center circle's framing and to the deck ties above. A lightning fire burned the standby power pole mounted transformers one evening in June 1950, with no direct damage to the bridge.

Records for the 1950s and 1960s show that the bridge underwent a series of retrofit improvements. Steel ties were installed under the rail locks in August 1954. A general machinery cleaning and overhaul occurred in May-October 1956, despite a breakdown of the draw lock gears at the Portland end in March 1957. The quadrant gear's teeth broke and allowed half the quadrant and its counterweight to drop into the river. The 1957 breakdown is reported to have delayed train service until it was repaired. Other major machinery repairs are reported for November 1958 and July 1959, bull shaft replacement and other turning machinery gears replaced and spares made by Monarch Forge and Machine Works in Portland. Spares were reported to be stored in the Vancouver, Washington, roundhouse. The stored gear spares were destroyed in a January 1971 fire at the roundhouse.

A September 1957 collision with the center Pier III by a Tidewater-Shaver ammonia barge resulted in Gunnite concrete repairs being made to the monolithic structures.

The Finnish steamship, Korsholma, hit and collapsed the downstream draw protection in October 1957. The vessel's prow was badly bent and opened by the impact (see HAER photographs, OR-7-47 to OR-7-49).

The air compressors were replaced in February 1958. The old compressors were found to be not beneficially repairable.

Some replacement of upstream draw protection was done in October 1958 due to age and rot. During this work, the General Construction Company barge was struck by the tug Tidewater Shaver.

The General Construction Company contracted to replace some of the draw span's structural steel in 1959, beams and girders, bottom laterals, top stringer laterals, top and lower stringer flanges, top cover plates on floor beams, and miscellaneous pieces.

The 1960s saw major efforts to clean up the Willamette River's pollution and to rehabilitate the bridge. River water quality monitoring stations were installed on the shear fence by the U. S. Public Health Service in 1961 and continued by the succeeding EPA in the 1970s. Some corroded steel structural sections were replated in 1960 and measures were taken to protect other members from corrosion damage, primarily deck-supporting members. The removal of the gas standby generation equipment and improvements to the bridgetender's house were done in November 1963, the same year that the Hayden Island trestle was replaced by a fill. Marine band VHF radio telephones were installed in 1967 to facilitate communications with river vessels, at the request of the Columbia River pilots.[26] In 1974, the railroad sought Coast Guard approval to use the radio-phone communications to better coordinate the priorities of trains versus river traffic, so as to avoid delaying Amtrak passenger trains and losing "on time" bonuses. Other recorded work on or about the bridge was for the 1967 dredging of the "40-Ft. Channel to the Sea," the installation of river mile markers on the draw rest in 1961, and alterations and maintenance to the submarine cable by Pacific Power & Light Company in 1967.

In June 1968, jurisdiction for bridge permits over navigable waterways was transferred from the Corps of Engineers to the Coast Guard under the Secretary of Transportation.[27]

The 1970s saw a continuation of the typical pattern of three to four accidents between river vessels and the bridge's shear fence. The General Construction Company made most of the repairs. The records show a routine pattern of maintenance work and repairs of motors, rail locks, submarine cables, dredging, safety devices and occasional fire damage.

In an attempt to mitigate the difficulty with ship passage through the draw, new navigation lights were installed in 1976. In December of that year, the Port of Portland announced plans for building the West's largest drydock, sufficient to service the maximum width of a vessel that could pass through the Willamette Bridge's draw This expansion of the Port's facilities to accommodate larger ship repairs began to put pressure on the bridge for its replacement with a larger draw opening.

Through the Willamette River Bridge 5.1 regularly pass about 24 trains per day, most Amtrak and through freights, fewer trains than before the several

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26 Letter, October 1966, Col. R. Pilots Assn. to BN Railroad.

27 Department of Transportation, USCG, letter, June 21, 1968.

roads consolidated into Burlington Northern. Each of the Great Northern, Northern Pacific, and SP&S had separate marshalling yards and maintenance facilities in northwest Portland. Now the trains are made up and maintained in Vancouver and the Portland yards are being considered for development as business and industrial sites. The bridge is opened and closed about 300 times a month, most on weekends when there is more pleasure boat traffic in addition to the commercial.

Planned Replacement

The October 27, 1978, collision of the Norwegian ship, M/V Marie Bakke, with the draw protection and the opened draw span resulted in the first major rebuilding of the draw span and machinery in its seventy years. The impact demolished a substantial part of the downstream shear fence, damaged the Portland end of the span, and moved the span about four feet upstream, breaking its center pivot, many gears, and the roller nest. There was danger that the entire draw might fall over into the river. The operator was up in the bridgetender's house at the time and was pretty well shaken up by the accident. All power and telephone communications were cut, with only the battery-powered radio-phones to request help.[28] The accident, the expense of the repairs, and the delays occasioned by the bridge being out of service to both railroad and river traffic for three months brought concerted action to bear on its replacement with a larger draw span.[29]

Studies on the feasibility and costs to replace the draw began immediately after the repairs were made. Preliminary meetings were held during 1979 and formal hearings conducted by the Coast Guard in September 1980. Testimony generally emphasized the hazard to navigation presented by the existing bridge, its narrow draw passages relative to the increasingly large vessels visiting the Portland harbor and its repair facilities upstream to the bridge, and the cost-benefits to the city and region if a larger span was installed. Except for the delays caused to the railroad's trains when an accident closed the bridge, the bridge is otherwise very satisfactory to the railroads and has been found to be in excellent condition, especially following the major repairs in 1978. It has been through the funding of the Truman-Hobbs Act that the planned replacement is made possible and the determination that it is in

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28 Report by Modjeski and Masters, January 24, 1979, and oral history interview with Louis deGrandpre and Art Hansen, March 14, 1985, appended to this report.

29 Repairs cost $3.3 million and required four months of restricted passage by river vessels. This was primary in the Coast Guard's findings that the bridge's "obstructiveness" justified its replacement (DOT, U. S. Coast Guard letter, August 19, 1980.

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the public interest that the present bridge draw be replaced with a larger one.[30]

The new draw will require the removal and demolition of the existing swing span, its center Pier III, and the associated shear fence structures. The two draw-end rest piers, numbers II and IV, will remain in place along with the other fixed spans and piers. The two draw rest piers will be encased in the new foundations of the new lift span towers which will rise vertically up over the ends of the side spans. A new vertical lift draw span will be installed between the two towers to provide an approximately 500-foot-wide clear draw opening and 180-foot vertical clearance in the draw. Engineers for the new draw are Howard, Needles, Tammen & Bergendoff, Architects-Engineers-Planners, Kansas City, Missouri. Construction is planned to begin in 1985 and to be completed in 1988.

Replacement of the Willamette draw span is estimated to cost $34,929,000, with the Coast Guard paying $34,100,000 and Burlington Northern paying $829,000, as appropriated under the Truman-Hobbs Act.[31]

The new bridge is being designed so that the railroad will have the option of remote control operation from the Vancouver Bridge if Coast Guard approval is given. It is to have automatically sequenced electronic controls and safety devices for its operation, so that the operator only has to check the status panels and lights and initiate the opening and closing sequence with a single switch. There is to be a sophisticated signal and monitoring system installed to facilitate all-weather communications with river traffic and insure safe operation when attended or remotely operated,

Most importantly, the construction schedule for the replacement work estimates that only four days normal train interruption will be required by the draw span replacement. The new towers are to be built, while the existing bridge is in normal operation for trains and river traffic. The new draw span is to be constructed at a nearby site. When construction is completed, the new draw span will be floated to the opening while the old draw is being demolished, jacked into place, and fastened to its new supports and lifting cables, ready for testing and operation within four days following closing of the existing bridge for the swing span's removal.

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30 BN records contain clippings from Daily Shipping News, Daily Journal of Commerce, and The Oregonian, for spring and fall 1980 which chronicle the public hearings leading to the replacement decision.

31 USCG Environmental Assessment Section 4(f) Statement, August 13, 1984.

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Linda S. Dodds, History Resources, Portland. Consultant for oral histories.

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Ann Huston, Division of National Register Program, Western Regional Office, National Park Service, San Francisco. Assistance with archival requirements.

Lewis L. McArthur, Historian. Consultation on bridge's history.

Members of Oregon Chapter, National Railway History Society. Consultation on documentary and photographic resources.

Nick Mpras, Historian, U. S. Coast Guard. Background information.

Oregon State Historic Preservation Office. For copies of U. S. Coast Guard 4(f) report and historical information.

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Jack P. Shedd, Engineer, HNTB. Assistance with obtaining historic photographs and information on lift span.

Fred Small, Photographer, Portland. Consultant for field photography.

Dwight Smith, Environmental Section, Highway Division, Oregon Department of Transportation, Salem. Information on Oregon's historic bridges.

Staff of the Oregon Historical Society for documentation and photography assistance.

Repositories of Bridge Historical Documents

Correspondence and drawings:

Burlington Northern Railroad
1101 NY Hoyt Street
Portland, Oregon 97209

Office of Bridge Engineer
Burlington Northern Railroad
2000 FIC Building
999 Third Avenue
Seattle, Washington 98104

Photographs and records:

Oregon Historical Society
1230 SW Park Avenue
Portland, Oregon 97205

Original archives:

Modjeski and Masters, Engineers
Harrisburg, Pennsylvania

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